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ABSTRACT

This paper summarizes the experiences acquired during the European research project, "On the Move," and draws on some conclusions on how mobility will impact information service providers. The paper begins with a definition of mobile information systems and explains the On the Move project; the goal of On the Move is to develop a "mobile middleware," a software that intercedes between the computer and the communications device and manages connectivity in the manner best suited to this. Following an examination of the aspects of mobility is a discussion of the information aspects, especially how the information demanded changes when the user can access it free from constraints in time and space. Discussion then moves to how this information can be obtained by the provider, which existing systems can be used and which new systems and information must be created. The paper concludes with a discussion on presentation aspects, as the same information will need to be presented in different ways, depending on the user terminal and the transmission network capabilities. (Contains 21 references.) (Author/AEF)

On the move: mobile information systems

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Abstract: *This paper intends to summarise the experiences we have acquired during the One the Move project and to draw on some conclusions on how mobility will impact information service providers. It begins with a definition of mobile information systems and explains the On the Move project. We then look a little deeper into the mobility aspects. Following that is a discussion of the information aspects, especially how the information demanded changes when the user can access it free from constraints in time and space. We then discuss how this information can be obtained by the provider, which existing systems can be used and which new systems and information must be created. The paper ends with a discussion on presentation aspects, as the same information will need to be presented in different ways, depending on the user terminal and the transmission network capabilities.*

Keywords: information services, mobility, multimedia, wireless connectivity, information provision/digital publishing, the future of online

1. Introduction

During the course of the On the Move experiment, we have come across several important issues concerning provisioning a mobile information system. Chief among these is that the presentation must adopt to different terminal capabilities and bandwidth, and be coded accordingly; and that information can become geographically dependent and change with the location of the user. To provide information structured in this way will challenge current systems and infrastructures.
The bandwidth issue is widely expected to be solved by the advent of UMTS, the Universal Mobile Telephone System. New problems will then arise concerning video in the interactive wireless environment.

2. What is a mobile information system?

In the future, the boundary between the local area network and global connectivity networks will disappear. This is true also for mobile systems (Ref 20). This means that existing information systems will be globally accessible but it also means that users will be able to access information which needs to be geared towards them while they are mobile.

2.1. What is On the Move and how did we get involved?

On the Move is a European research project funded by the European Commission DG XIII through the ACTS programme. This is a research programme within the fourth framework of European research programmes, with the intention of furthering European research in leading-edge technologies (Ref 1). The partners include Ericsson Radio Systems (Sweden), Bonnier Media Lab (Sweden), KTH (Sweden), SICS (Sweden), EED (Germany), Siemens (Germany), RWTH Aachen (Germany), Burda (Germany), Sony Europe (Germany), Tecsi (France), IBM Europe (France), CWC (Singapore), Iona (Ireland) and BT (United Kingdom).

The ACTS programme is also somewhat different from the earlier RACE and RACE II programmes in that its purpose is not basic research and basic technology, but applications of technology. The programme is still pre-competitive, which means that companies that normally are competitors should be able to cooperate.

The goal of On the Move is to develop a 'mobile middleware', a software that intercedes between the computer and the communications device and manages connectivity in the manner best suited to this. The project is geared towards Universal Mobile Telephony System (UMTS), the mobile telephony system of the future. This system will build on existing mobile technology but have a transmission capacity of 2 Mbps per user. In comparison, current mobile telephones have a capacity of 9.6 kbps per user and an ISDN line of 64 kbps per user. To put this in perspective, a text transmission works fine at 2.4 kbps, but a World Wide Web page with pictures tends to be perceived as slow at 28.8 kbps, and a normal video transmission requires at least 256 kbps.

UMTS is expected to be available sometime after the year 2000 (Ref 20) and the work on standardising it is

currently going on. However, it is not very likely that the system will be deployed all at once. Instead there will be islands of GSM and GSM+, a next-generation development of GSM with capacities of up to 64 Mbps per user. There are also other concerns, like security and charging, that need to be addressed. The On the Move middleware will manage this and shield the interaction with the transmission network from the user.

One of the prime applications of mobile systems is expected to be information services and this is where the Bonnier Group comes in. A $1.25 billion corporation based in Scandinavia, we already have substantial traditional electronic information services (Hoppenstedt-Bonnier in the UK; Affärsdata, Findata, Bonnier Kreditfakta and Nyhetsbyr—n Direkt in Sweden; Telebörsen in Denmark) as well as extensive Web publishing activities. We were approached by Ericsson to participate in the On the Move project.

Testing a software product is normally either done through a technical verification procedure (in the case of systems software, for instance) or in a user test. The On the Move project will do so with extensive user testing (extensive for the telecommunications business, anyway) (Ref 13).

It is in this context that we have been confronted with the special demands of mobile users and some of the issues that will need to be addressed by future information systems for mobile professionals.

As publishers, our interest lies mainly in the information service. To create an information service that would test the functionality of the underlying communications software, simultaneously giving something to the user, we provided the following:

- a personalised information service, enabling the user to customise his or her presentation;
- adoption of the layout and presentation to the transmission capacity of the medium (varying from 2 Mbps, which enabled video; to 9600 bps, which was at most sufficient for text);
- location dependent information (as the user moves from one city to another, the 'current city' information will have to change);
- multilingual information.

Personalisation is especially seen as a very important feature of future information systems (Refs 12, 16, 17).

2.2. Mobility issues

Often, mobility is confused with moveability. In the early days of mobile telephony this was understandable: it was not possible to use a mobile telephone except in a car. Today the handset is easily carried in the pocket but it is still mainly usable for voice communication, even though the transmission is digital, and thus should be able to handle data communications as well (Ref 20).

Mobility also comes in two basic flavours: the user being mobile and the information being mobile (Ref 2). Basically, in the first case you access existing systems from a mobile device and in the second case you access information that is being adapted to you where you are.

2.2.1. The user/terminal being mobile

The first set of problems in a mobile information service derives from the fact that the terminal is mobile. This implies several things (Ref 11):

- the network capacity is low;
- the terminal itself has several limitations;
- the user can move from an area with good reception to one with bad, or none at all, with very short notice;
- in the case of a news service, the news feed must be kept coming even if the user moves to an area of bad reception;
- if the user is cut of from reception, some mechanism must be provided to handle the information.

We will look a little deeper into each of these points.

- *The network capacity is low*. Universal Mobile Telephony System (UMTS) will provide a capacity of 2 Mbps per user. In comparison, current mobile telephones have a capacity of 9.6 kbps per user and an ISDN line of 64 kbps per user (experimental next-generation GSM systems have been demonstrated with transmission capacities of up to 64 kbps). To put this in perspective, a text transmission works fine at 2.4 kbps, but a Web page with pictures tends to be perceived as slow at 28.8 kbps and a normal video transmission requires at least 256 kbps.
  This implies that except for islands of UMTS connectivity, video is out. As anyone who has tried knows, on a normal GSM line ordinary Web services are out too. However, our experiences as publishers tell us that the nicer the packaging, the higher the user acceptance. So while information will have to be provided as text over the GSM line, it still will have to be nicely packaged.
- *The terminal itself has several limitations*. Currently laptops are the mobile terminal of choice. However, they are heavy and battery life is short. It is very likely that information systems of the future will look more like the Nokia 9000 communicator (Refs 10, 16, 18). This in turn implies limitations in user input and screen capacity (the least of these being that it is black-and-white). These limitations must be conceded when presenting information.
- *The user can move from an area with good reception to one with bad, or none at all, with very short notice*. It is unlikely that all of Europe will be covered with UMTS at once (Ref 20). Even today, GSM does

not cover all of countries like Sweden, Norway and Finland, where penetration of handsets is highest in the world (Ref 15). Also, radio networks are prone to service quality loss, to cite the reflections of TV signals in London's Canary Wharf as an example. Solar radiation can also cause disturbances and it is unlikely that the system will cover all underground traffic systems (subways, tunnels and so on). This means that some mechanism must be built into the system to handle interruptions and quality changes.

- *In the case of a news service, the news feed must be kept coming even if the user moves to an area of bad reception.* This implies that the quality changes will have to affect the presentation of information, probably according to a list of priorities set up by the user. This in turn implies that there must be a personalised handling of the connectivity.
- *If the user is cut of from reception, some mechanism must be provided to handle the information.* Even if the network adapts to quality change, or even handles interruptions of service, it will be meaningless to the user if he is flooded with telegrams when he has been out of the network for a while. This is especially pertinent in cases where he voluntarily switches the receiver off (for example, during a meeting). That, in turn, implies that the information service must handle these cases.

2.2.2. The information being adopted to mobility

Information itself can adapt to the user being mobile. Today there are receivers for the Global Positioning System (GPS) available on a PC card. These can be used to create position information, possibly in conjunction with the GSM network (Ref 9). If this information is fed back automatically to the sender from the receiver, the information presented can change as he or she moves from one place to another. One of the simplest cases would be city information. However, there are several problems with this approach (Ref 11). For instance, what are the boundaries of the current information set? How does the system receive coordinates? What is the resolution of the database and how is this fed to the sender of information? Should this change if the user changes terminal, or quality of service changes? What if he is in a high-speed plane, or a train?

3. The On the Move information system

In the On the Move project we have developed an information system to meet at least some of the requirements stated and implied above.

The information system is divided in two: one German and another Swedish. This is partly due to the initial availability of the information in one language only (see Section 6 below) but also to the fact that the two systems each work in a different test bed: The Swedish system is intended to test bandwidth adaptability in an information stream environment while the German system is intended to test location dependency. The system runs on standard laptops and is based on the Web with Netscape Navigator as a front-end. The software part has been developed by GSI Tecsi of France while the content is obtained from existing Bonnier and Burda systems (Ref 13).

The Swedish part is a fairly simple information system, based on feeds of news telegrams from Nyhetsbyr—n Direkt and the Web page of *Dagens Industri*, our business newspaper, who publish full listings of the Swedish stock exchange (Ref 11). This system, shown in Figures 1 and 2, can be fully customised by the user by feeding in keywords and stock names to create a personal portfolio of news and stock exchange information.

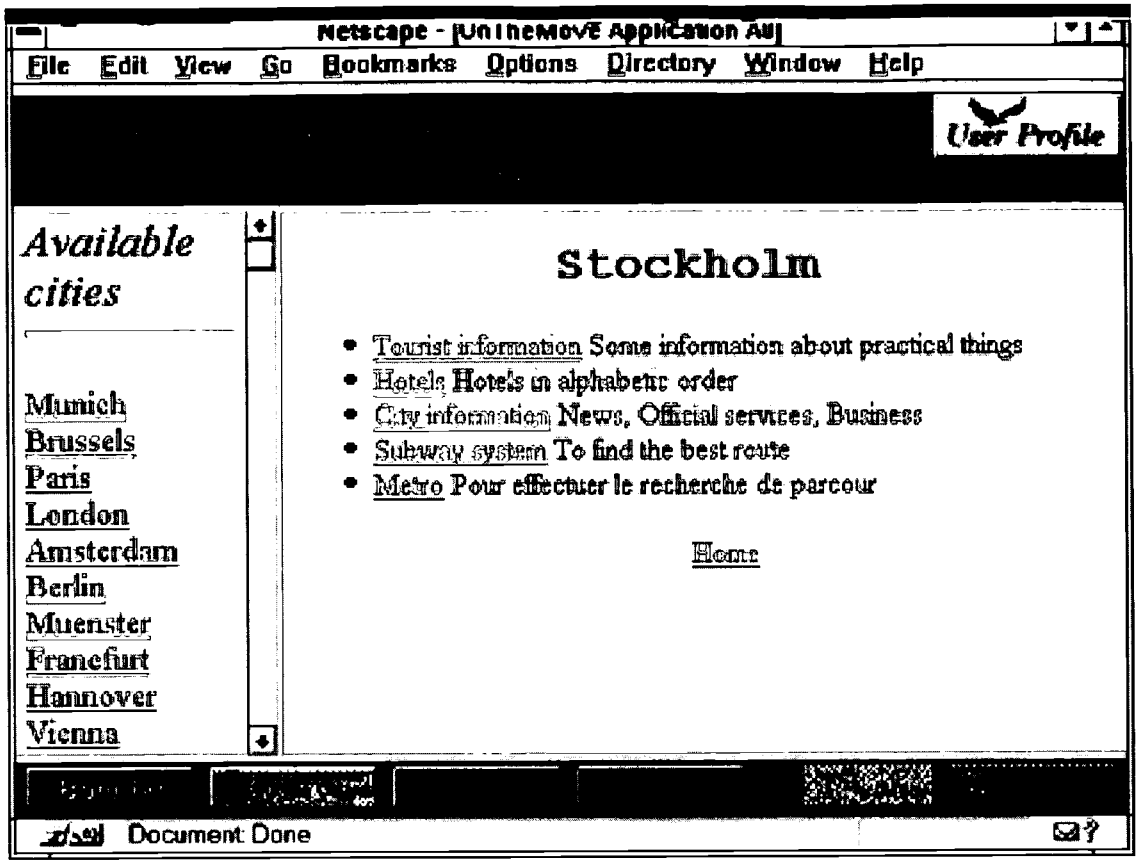

Figure 1: The Swedish application.

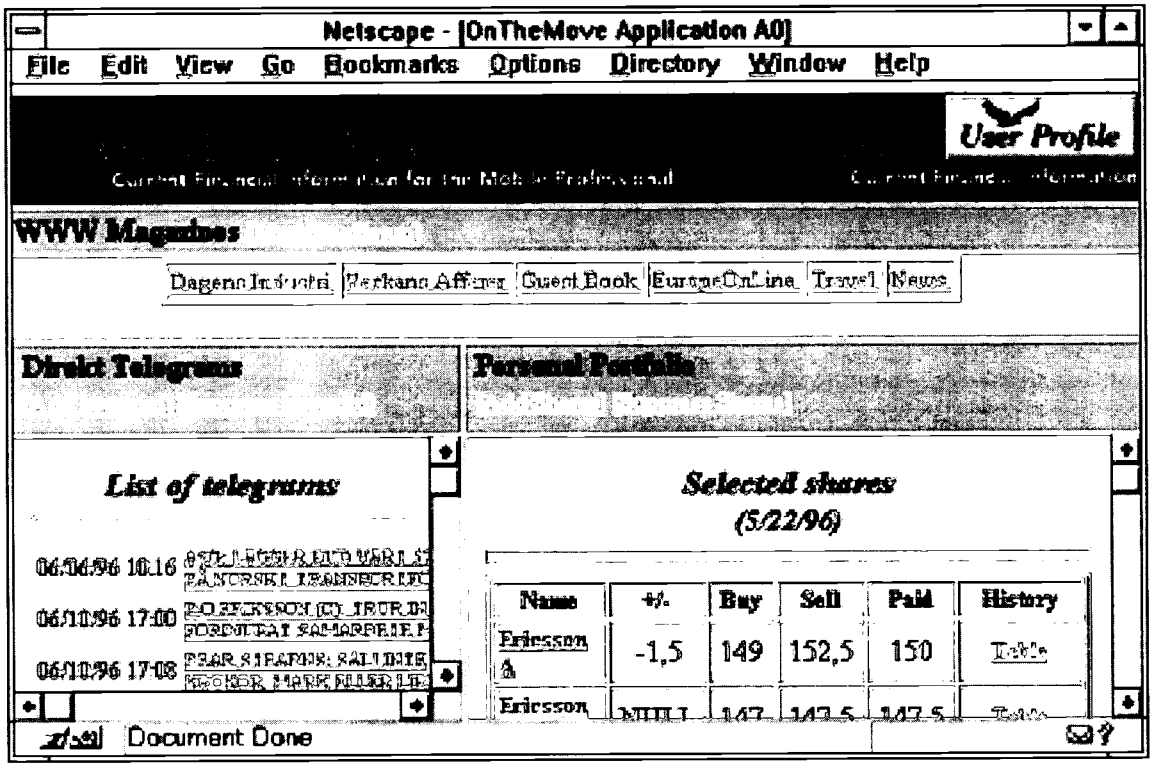

Figure 2: The German application.

The German system is based on existing databases of travel information, obtained from the Burda group, as well as news from Europe Online and links to Internet sites. The primary goal of this system is to manage the localisation of information. To do this, the server retrieves the location information from the client and automatically transmits the relevant pages.

The system will be tested by two users at the time. In the Swedish test site they use portable computers with a wireless local area network (LAN) connection to simulate UMTS capabilities (the wireless LAN having a capacity of 2 Mbps), and a mobile telephone to test GSM. In the future, the middleware will automatically manage the handover between the two. In the German test site the test uses GSM and the German Modacom network.

The test set-up has been provided to users during a field trial in June to September 1996, and a modified and developed version will be used during the first field trial of the middleware software in march 1997.

Several of the issues raised above are addressed in this system.

In the next phase of the project, these two parts of the system will be merged and create a single, multilingual, multi-national, multi-locational information system. However, using and building the system has taught us a lot about the questions posed above. We will revisit them and see how the current system addresses the different aspects of mobility, and how we can handle them even more efficiently in the future.

The system addresses the points and above as follows:

- *The network capacity is low and the user can move from an area with good reception to one with bad, or none at all, with very short notice.* The system manages this by transmitting information as text when required. It must also be able to change from graphic to textual presentation when required. This changeover is currently handled manually but in future versions will be managed through the On the Move middleware. This also applies if the user changes terminal. This, in turn, means that there must be a personal connectivity profile that changes when the users changes terminal, network bandwidth, location and other aspects of his connection.
- *The terminal itself has several limitations*. The graphics have to be clear and there have to be alternatives to the graphics. Graphics themselves must be presented in such a manner that they are readable on a black-and-white terminal, not only for users with black-and-white monitors but also for users who are colour blind (Ref 5).
- *In the case of a news service, the news feed must be kept coming even if the user moves to an area of bad reception. If the user is cut of from reception, some mechanism must be provided to handle the information.* This impacts presentation more than actual information management. We have solved it by only presenting the headlines and letting the user click to go to the actual text. In this manner the backlog of telegrams when the user has been switched off for a period of time becomes easily manageable and it is possible to skim through them. Also, as information is personalised the number of items transmitted is far lower than in an unfiltered news service.
- *If this information is automatically fed back to the sender from the receiver, the information presented can change as he or she moves from one place to another. How does the system receive coordinates?* Currently this is managed manually. In the future versions it will be handled through the middleware.
- *What are the boundaries of the current information set? What is the resolution of the database and how is this fed to the sender of information?* This is one of the thornier questions in information management. How to map objects in a database to a set of coordinates is by no means self-evident. While there are standard methods for coordinate representation, the storing of objects varies from one Geographical Information System (GIS) to another.
- *What if he is in a high-speed plane, or a train?* In this case the user is on the move (pun intended) and the coordinates will change very rapidly. Indeed, they will change faster than a GSM system can cope with, as these are only developed to handle handover from one cell to another of devices moving at speeds of less than 200 km per hour (Ref 20). How to solve this is not something we have tried to address in the current system.

4. Information of interest while on the move

Without deeper studies into information services, market surveys, focus groups and so on it is very hard to say anything definite about what kinds of information users feel are interesting while mobile. Some aspects of user behaviour have become evident, however.

4.1. Terminal mobility impact on information demand

In a system where the user accesses existing information services, be they internal or external to the company, the fact that he is mobile will put demands on the presentation of information. It will also create a need to ensure that the information which the user used to request from his desktop is available to him as he is mobile. If he is mobile across several time zones, the assistance in searches provided by an information broker or a librarian may not be available without great inconvenience to both, especially if the search requested is urgent. This implies the user will demand a simpler user interface that he himself can use without assistance.

It also implies that presentation should be kept simple while at the same time being appetising (Ref 10). This

may sound like a contradiction in terms but it is not. In the extreme case, the user may demand information over a mobile telephone without a computer attached in the form of voice-recognition. Presentation must be flexible enough to accede to this. Fortunately, developments are going on, especially in the World Wide Web community, that take this into account (Refs 19, 21).

4.2. Information mobility impact on information demand

While terminal mobility can be addressed within the framework of existing information services (albeit with a little squeezing), the mobility of information is not managed so easily. To present a localised information set, the information must be structured into objects and these must be tied to coordinates. In the simplest case, the object is a city or even a country, and the coordinates the latitude and longitude bounding this place. However, just looking at a map tells us this picture is an oversimplification. It is only in America that states and cities have straight edges. This translation, and how it should be managed is likely to provide a lot of headaches to future information system designers (Ref 11).

5. Obtaining information

The process of provisioning an information service such as the one described above is not simply a question of redressing existing information services in mobile suits. Aspects such as filtering of information on different personal criteria, localising information and differing presentation on bandwidth impact the information sources in sometimes profound ways.

5.1. Existing sources

As described above, the mobility of the user will impact the presentation of information profoundly.

One aspect is a trend that is also evident in fixed systems, albeit not as strongly. It is the trend towards dynamic presentation of information sets. As the user becomes mobile, the location becomes one more item of interest in the user's personal information profile. Even for the small number of users in the On the Move project experiments, this has meant that there will never be two users with one completely overlapping set of interests. To facilitate presentation we created fixed layouts in the World Wide Web into which the information was fed.

There were other aspects that put greater demand on the information structure, however. In the system there is a possibility to select the bandwidth of the network. In the low bandwidth case, the presentation will not contain video and graphics. Currently this means that we have to have two versions, one with graphics and one without. While this is nothing out of the ordinary to most Web designers, the next step is video that can adapt to lower transmission capacities. This will be covered in some more detail below.

But this adaptation is not limited to video only. Text may also be adapted, as well as pictures, not only by throwing undesired items away but also by filtering out information that is not necessary for the content or adding information that enhances understanding. A local resident might not need any reference on a local news item but a foreign visitor might (Ref 8). Such filters exist but are so far only experimental; although it is easy to see their application to mobile systems where bandwidth may be a scarce resource.

In a personal information system, it must be possible to apply personalisation to information. We did this in two ways in the different versions of the system. In the German version, the user can select news items from a menu where the subjects areas are pre-coded into the system. In the Swedish system the user inputs keywords and the server then dynamically retrieves only those items where the keyword occurs.

These two ways of managing information are suited to very different information systems. In the first case there must of course be a way to code the information with the relevant subject areas. These must be either input manually or extracted from the information. Currently they are input as the text is input. This means that the method is more suited to large databases, fairly static, with a slow update frequency (Ref 11).

The method of retrieving items based on keywords is fairly CPU-consuming but not unreasonably so. However, as the experiment has only had two simultaneous users so far there is no real way of knowing where the ceiling is (Ref 7).

But the real implication of personalisation is for traditional systems. To be able to provision information in personalised formats to a large number of users on the fly, your database has to be very flexible and very fast. Traditional sources of information like database hosts are not in my view likely to disappear, but they will need to adapt.

5.2. New information sources

An even more interesting set of problems occurs in video transmission, however. We have not attempted any user trials with this, conducting only small-scale experiments, but this is the area where bandwidth adaptation really comes into play. In the most extreme case, the video is deferred altogether; in the second most extreme, sound only is played. There is then a rising scale of throughput up to the full broadcast quality video — something that is very bandwidth consuming, using up all the transmission capacity to the mobile unit. In an MPEG coded film, different bandwidths can for instance easily be attained by successively decreasing the number of I-frames (Ref 14). Other, more sophisticated systems of video encoding are also appearing (e.g. FLIIT) (Ref 6).

This has vast implications for the production and encoding of video information, demanding that all video

sequences be able to adapt to the capacity of the medium in this manner. Looking at the different encoding schemes, it is not simply a problem of translation: the video has to be encoded anew and this implies the source is still available.

6. Presentation aspects

In a personalised system the user will be able to choose not only content but also presentation. This implies that there will be no fixed layout. The *JavaBlitz* personal newspaper (formerly *Krakatoa Chronicle*) (Ref 4) is an example of this but it does not take multimediality into account, and neither does Fishwrap, a similar project at MIT (Ref 3). Still, it is fairly safe to assume that users will continue to demand more presentation capabilities rather than less. A system where only text is presented will not gain as wide acceptance, but this is one of the cultural dependencies we have discovered during the project. German users tend to state that they are more ready to receive information in text-only format than Swedes for instance.

To retrieve information dynamically based on keywords demands that the stream of information be either fairly slow or based on fairly short items (no more than 50–75 words, as far as we can see). This is not a technical limitation but has more to do with the user's capacity of reading items off the screen. While it is possible to read many items fast, the user will then need to concentrate on the screen continuously. Our system was designed for users who are accessing it fairly infrequently (4–5 times per day). This implied that too many items would generate information overload (Ref 7).

An interesting experience is also that users tend to start by a large number of keywords and then de-select them as the time passes. This implies that the user concentrates on his areas of interest rather than broadens them. We believe, although this has not been substantiated, that the users use the system for the things where it brings distinctive advantages, such as rapid updates in a narrow field, and not for general information where the regular news media are more convenient.

One of the more pertinent questions is multilinguality. If the user is able to create his or her own personal profile, why limit it to English? However good at English we non-English speakers get, there is a security in receiving information in one's own language. Even our test users, sophisticated though they are, preferred the Swedish information to the English (Ref 7). If an information set is to be presented to a larger user group, native in several languages, this implies that to be most comfortably accepted it has to be presented in their native languages. The personal profile has to contain the language preferences and act upon them. Incidentally, this holds true for both the surrounding navigation infrastructure (menus and so on) as well as for the information itself.

Of course, acquiring this information is a very different matter. In our system we simply buy it from news services. In an intranet it would have to be translated but would probably be so anyway. We can let the personalisation module of our system act on the information, since company names are the same in all languages; however, a table of 'business keywords' translating for instance interest in several languages could be constructed, and when the user chooses language preferences relevant keywords could be applied to the retrieval of information.

Cultural background is another aspect that heavily impacts presentation. The different impacts of colour are well known (Ref 5). Colour also has to be used judiciously with an eye to contrast. A very instructive exercise is to look at the page on a black-and-white screen.

When the user is mobile, we also have to take into account that not only may the bandwidth of his receiver be too low to receive multimedia information but it may also well be the case that his portable unit is something like the Nokia 9000 communicator (Ref 18), a device with a rather small screen but larger than that of a mobile telephone.

7. Conclusion

The On the Move project, while its main activity is to develop a software to manage the technical aspects of user mobility, has given rise to many questions concerning information use in a mobile environment, and some conclusions on how to adapt information to personalised systems or systems with varying connectivity bandwidths.

When presentation must adopt to different terminal capabilities and bandwidth, the information must be coded accordingly. Information may become dependent on a geographic location and change with the location of the user. The system must be able to change from graphic to textual presentation when required. This also applies if the user changes terminal. This in turn means that there must be a personal connectivity profile that changes when the user changes terminal, network bandwidth, location and other aspects of his connection.

Personalisation is another aspect of information adaptation. In a personalised system, the user will be able to choose not only content but also presentation. This implies that there will be no fixed layout.

To retrieve information dynamically based on keywords demands that the stream of information is either fairly slow or based on fairly short items (no more than 50–75 words, as far as we can see). This is not a technical limitation but has more to do with the user's capacity for reading items off the screen. While it is possible to read many items fast, the user will then need to concentrate on the screen continuously. Our system was designed for users who are accessing it fairly infrequently (4–5 times per day). This implied that too many items would generate information overload.

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Cultural background is another aspect that heavily impacts presentation. The different impacts of colour are well known. Colour also has to be used judiciously, with an eye to contrast. A very instructive exercise is to look at the page on a black-and-white screen. The graphics have to be clear and there has to be alternatives to the graphics. Graphics themselves must be presented in such a manner that they are readable on a black-and-white terminal, not only for users with black-and-white monitors but also for users who are colour blind.

Another aspect of personalisation is multilinguality. However good at English we non-English speakers get, there is a security in receiving information in one's own language. If an information set is to be presented to a larger user group, native in several different languages, this implies that to be most comfortably accepted it has to be presented in their native languages. The personal profile has to contain the language preferences and act upon them. Incidentally, this holds true for both the surrounding navigation infrastructure (menus and so on) as well as for the information itself.

As the user becomes mobile, the location becomes one more item of interest in the user's personal information profile. Even for the small number of users in the On the Move project experiments, this has meant that there will never be two users with one completely overlapping set of interests. To facilitate presentation we created fixed layouts on the World Wide Web into which the information was fed.

The information will want to receive the information he is used to requesting from his desktop while he is mobile. This implies the user will demand a simpler user interface that he himself can use without assistance.

User mobility forces the information provider to adapt to several technical limitations, such as the network capacity being low and the user being able to move from an area with good reception to one with bad, or none at all, with very short notice.

If coordinate information is fed back to the sender automatically from the receiver, the information presented can change as the user moves from one place to another. How to map objects in a database to a set of coordinates is by no means self-evident. While there are standard methods for coordinate representation, the storing of objects varies from one Geographical Information System (GIS) to another. If the user is in a high-speed plane or a train the coordinates will change very rapidly, which also may impact presentation.

In the On the Move system, there is a possibility to select the bandwidth of the network. In the low bandwidth case, the presentation will not contain video and graphics. Currently this means that we have to have two versions, one with graphics and one without. While this is nothing out of the ordinary to most Web designers, the next step is: video that can adapt to lower transmission capacities. In the most extreme case, the video is deferred altogether; in the second most extreme, sound only is played. There is then a rising scale of throughput up to the full broadcast quality video: something that is very bandwidth consuming, using up all the transmission capacity to the mobile unit. In an MPEG coded film, different bandwidths can for instance easily be attained by successively decreasing the number of I-frames.

This has great implications for the production and encoding of video information, demanding that all video sequences be able to adapt to the capacity of the medium in this manner. Looking at the different encoding schemes it is not simply a problem of translation: the video has to be encoded anew and this implies the source is still available.

But this adaptation is not limited to video only. Text may also be adapted, as well as pictures, not only by throwing undesired items away but also by filtering out information that is not necessary for the content or adding information that enhances understanding. A local resident might not need any reference on a local news item but a foreign visitor might. Such filters exist, but are so far only experimental; although it is easy to see their application to mobile systems where bandwidth may be a scarce resource.

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